
Space Weather Technical Forecast

Issued on Sunday, 05 March 2023 at 13:15 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: M-class flares (R1-R2; Minor-Moderate radio blackouts) likely. Chance of Minor Geomagnetic Storm G1 intervals. Electron fluence is Active.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with an M5.2 flare observed by GOES-18 at 04/1557UTC, which originated from sunspot region 3234, which has now rotated around the northwest limb. This produced an impressive and large Coronal Mass Ejection (CME), which has been analysed and is discussed below. There are currently nine numbered sunspot regions on the visible disc. AR3242 (Eki/beta-gamma-delta) in the northeast is the largest and most magnetically complex region on the disc, which now contains a 'delta' spot within its intermediate portion. AR3243 Dao/Beta-Gamma in the northwest continues to evolve, with a north-south orientation and some growth of its large penumbral spot. This will continue to be monitored for any further development. A newly numbered region 3246 has rotated onto the northeast limb, which is currently difficult to analyse due to foreshortening, although it appears to be showing a large penumbral leading spot, with some faint trailing spots emerging within its plage area. A better analysis of this region will be made once it becomes fully visible on the disc. Most of the remaining regions are unchanged uni-polar and appear inactive. There are currently no Earth-directed CMEs in the forecast.

Solar Wind / Geomagnetic Activity: The solar wind as observed at L1 by DSCOVR and ACE, has been firmly connected to a high speed stream (HSS) associated with negative polarity coronal hole 81, with the phi angle predominately negative (towards the Sun) throughout. Solar winds have been at strong to elevated levels, between 500-610km/s. The solar wind density was below average throughout. The IMF was weak throughout, with a peak of 7nT. The north-south component, Bz, varied between +/-5nT. The net effect of the above solar wind measures was for Quiet to Active geomagnetic activity (Kp2-4).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16 remained at Background levels. Electron flux at GOES16 has been moderate to high with a peak of 2420pfu at 05/1015 UTC. Electron fluence was just below the Active threshold (1e8 integrated flux), with an upward trend observed and a value of 8.97e7 integrated pfu recorded at 05/0000UTC.

Four-Day Space Weather Forecast Summary

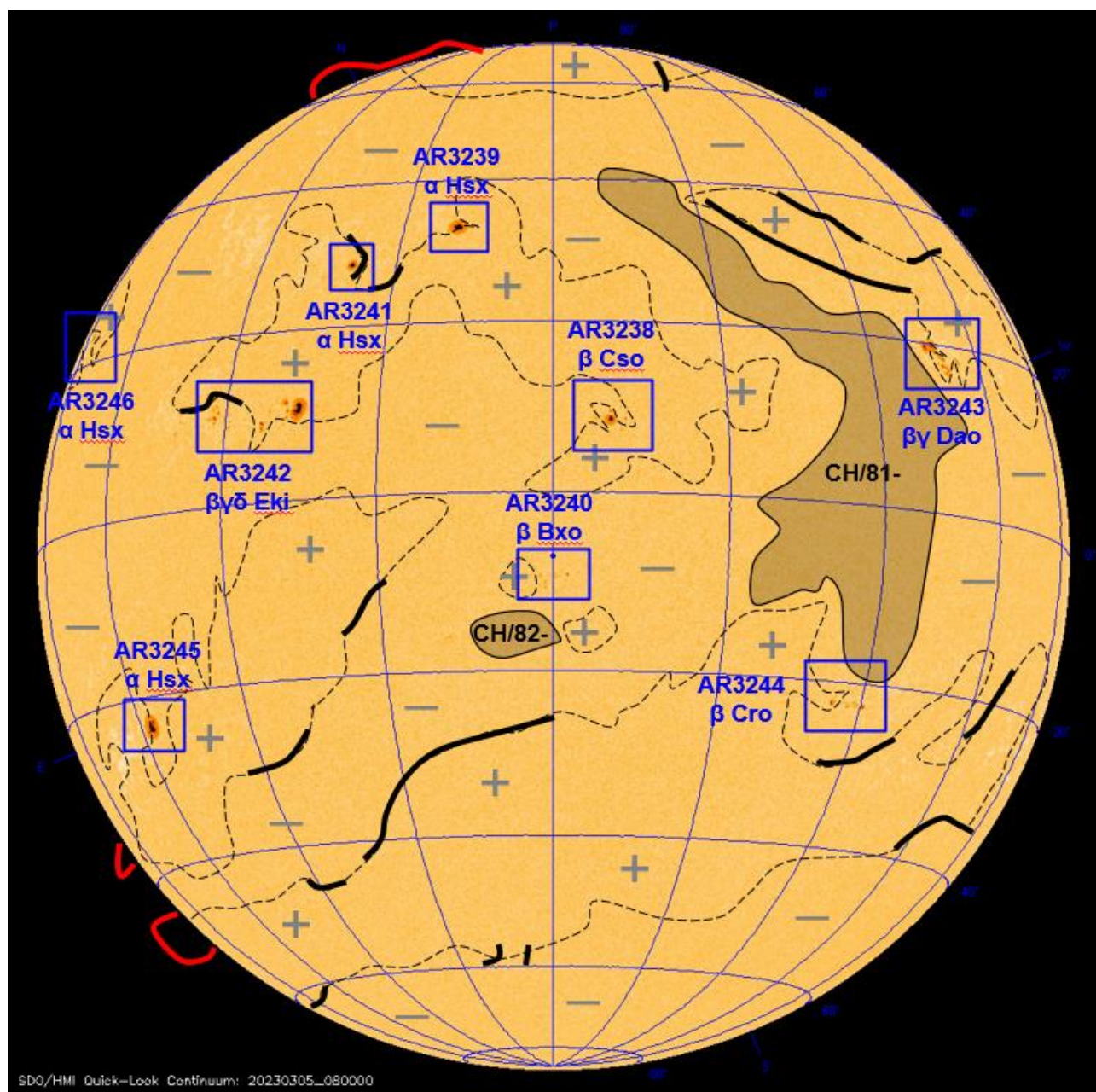
Solar Activity: Solar activity has been Moderate with two M-class flares observed in the past 24 hours, the largest being M5.2 at 04/1557UTC from AR3234 on the northwest limb horizon. Also observed an M1.2 flare at 04/1342UTC from AR3242. Though AR3234 has now rotated over the limb the flare risk remains elevated, particularly as new regions rotate further into view. Further M-class flares are likely with a slight (10%) chance of another isolated X-class flare.

Solar Wind / Geomagnetic Activity: No significant Earth-directed CMEs feature in the current
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forecast, however there is a low risk of a glancing blow from the fast CME associated with the X2.1 flare 03/1752 UTC, which could possibly arrive early on Day 2 (6th). A further CME was observed from the M5.3 flare and this may glance Earth of Day 4 (8th). Both flares mostly headed westwards from the Sun. The current geomagnetic forecast is dominated by the HSS related to CH81- which only looks to wane later into Day 2 (6th) or more likely Day 3 (7th). A chance of G1 Minor Geomagnetic Storms throughout, with the risk probably more heightened on Days 2 and 4 (6th and 8th) due to the possible arrival of the aforementioned CMEs glancing blows.

Energetic Particles / Solar Radiation: Although High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels, recent flare activity implies there remains a slight chance of protons increasing in the immediate term, reverting to the raw risk for the disc at nearer 5 to 10% into the new working week. Electron flux is likely to continue at moderate to high levels perhaps becoming suppressed at times given any further active geomagnetic activity. Electron fluence is above the active threshold, which is likely to remain above active levels through the guidance period, although the potential for more significant geomagnetic activity, especially for Days 2 and 4 (6th and 8th) leads to lower confidence.

Figure 1. Solar Analysis Valid 05/0800 UTC.



Key: Filament —, Prominence —, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

No significant Earth-directed CMEs feature in the current forecast. However there is a low risk of glancing blows from the CMEs associated with the X2.1 flare on 03/1752 UTC, and the M5.2 flare on 04/1557UTC, which Met Office ENLIL ensemble forecasts signaling could possibly arrive during Days 2 and 4 (6th and 8th).

The current geomagnetic forecast is dominated by the HSS related to CH81- which only looks to wane later into Day 2 (6th) or more likely Day 3 (7th). Earth is currently very close to the March equinox, and as such negative polarity features ought to be maximally potent. Earth does in fact reach its maximum southward limit with respect to the solar equator towards the end of this four-day forecast, before undergoing a gradual six-month journey back northwards. On last pass the analogous feature to CH81- gave a protracted spell of Active and then Unsettled Kp, with a relatively higher risk of reaching G1 expected on this pass, probably front-loaded to the main and most intense portion of the coronal hole which looks to peak overnight into Day 1 (5th) based on ENLIL output, but lower confidence resulting in a smooth partitioning of this risk between UTC days. Strong solar winds probably only slowly waning from Day 1 (5th) onwards. Overall a chance of G1 Minor Storms throughout, with the risk on Days 2 and 4 (6th and 8th) more associated with the possible arrival of the aforementioned CMEs glancing blows.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	10	30	20	30
Strong	G3	No	1	5	1	5
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

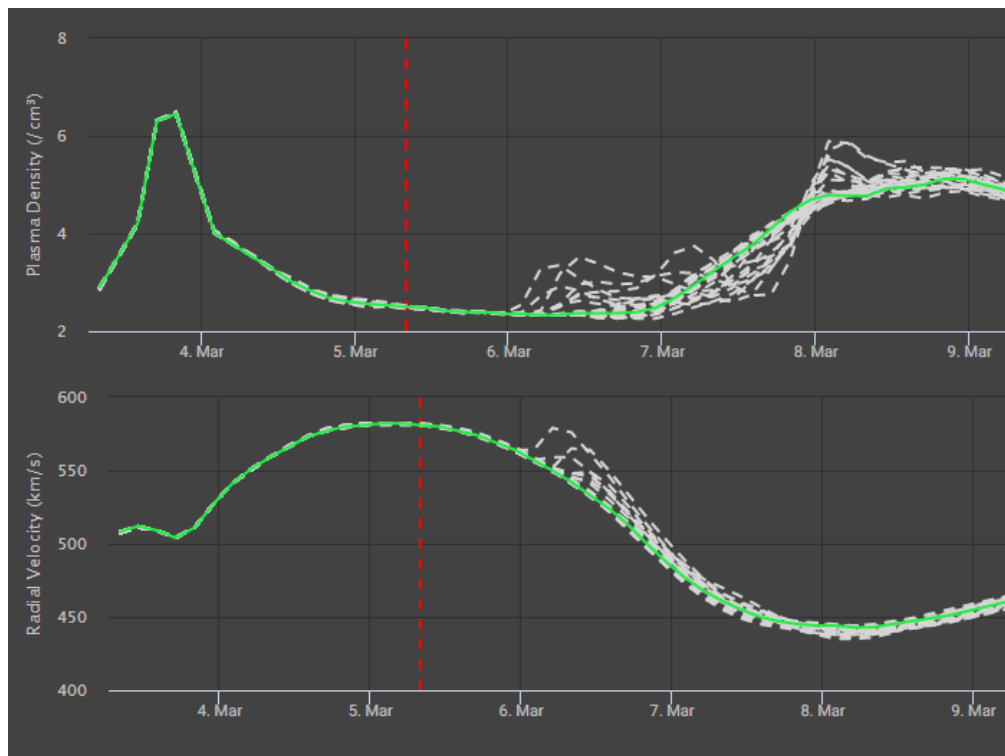
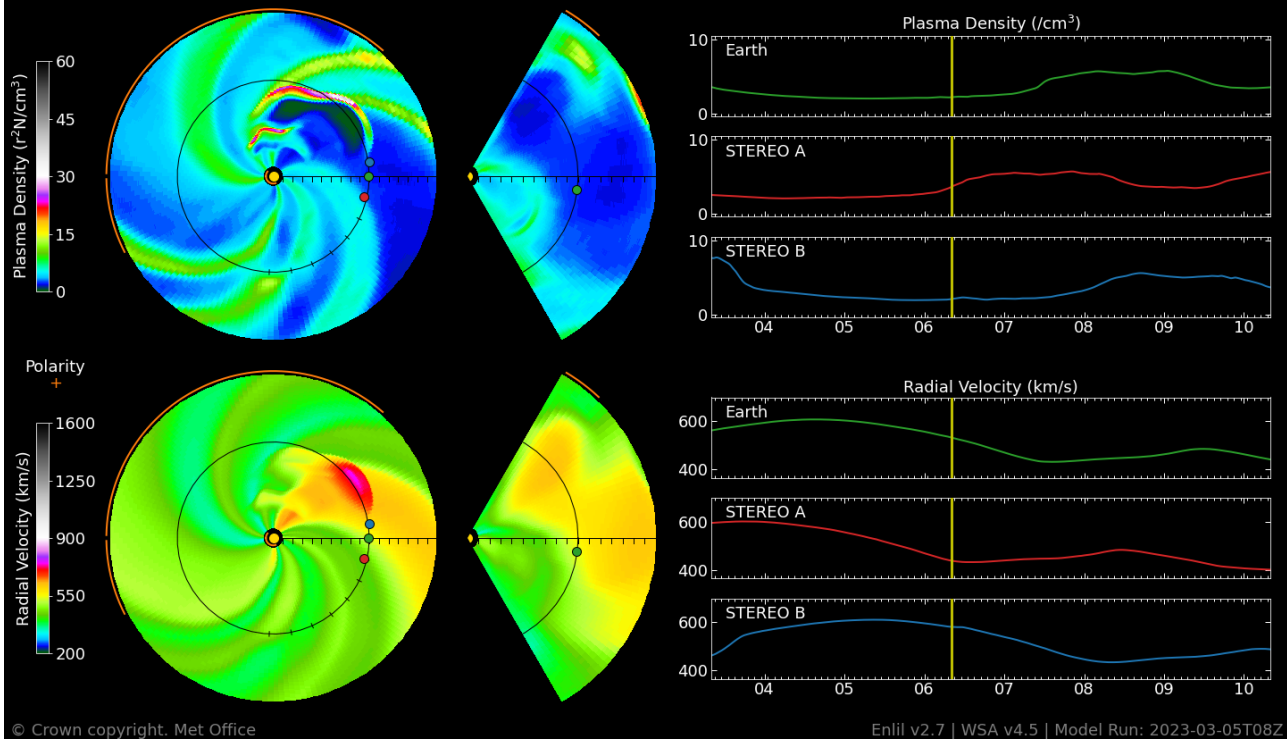
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
03/2256	Partial	AR3234	NW	802	06/0900 UTC	Glancing blow possible, but most material observed to west of solar disc

Figure 2: ENLIL and Ensemble shows possible glancing blow of CME on 6th March.



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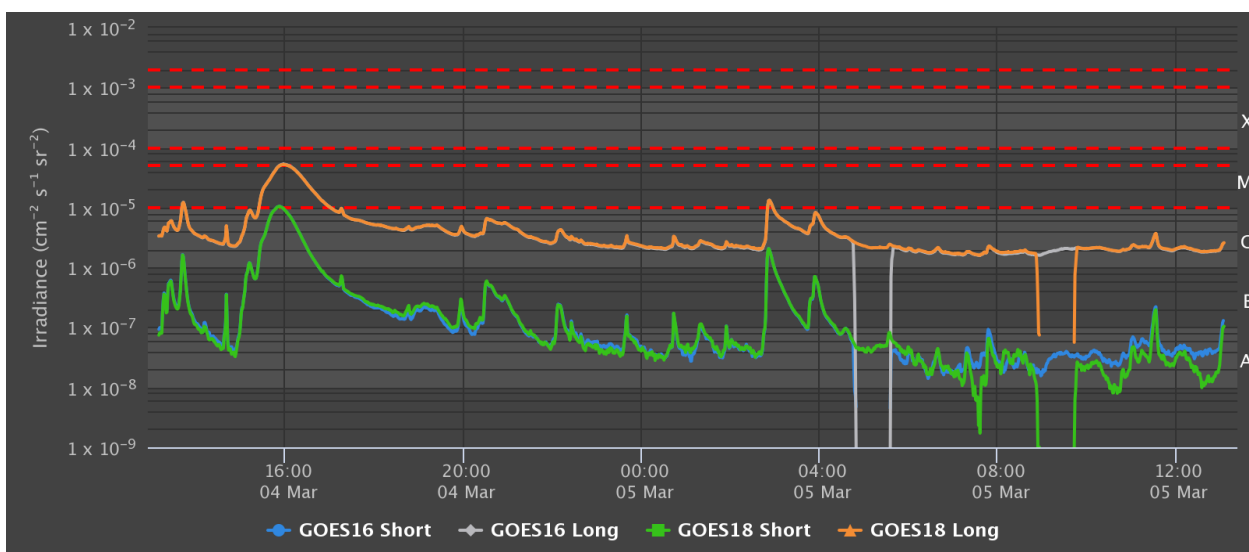


Radio Blackouts - X-Ray Flares:

There are currently nine numbered sunspot regions on the visible disc, with AR3234 having rotated across the northwest limb. AR3242 in the northeast is the largest region, which continues to develop, and now contains a 'delta' spot within its middle portion. This region has been classified as an Eki/Beta-Gamma-Delta. AR3243 Dao/Beta-Gamma in the northwest continues to evolve, with a north-south orientation and some growth of its large penumbral spot. AR3238 near centre disc has displayed spot emergence in recent hours, which is now classified as a Csi/Beta configuration. Most of the remaining regions are unchanged unipolar and appear inactive. A newly numbered region 3246 is rotating onto the northeast limb, which is difficult to analyse at present due to foreshortening effect, although it appears to be showing a large penumbral leading spot, with some faint trailing spots emerging within its plage area. A better analysis of this region will be made once it becomes fully visible on the disc. Far side data does suggest multiple sunspot regions massing behind the eastern limb with a steady stream looking to emerge onto the visible disc during this forthcoming guidance period. Their contribution to any risk increase into the coming new UTC week is not assured but for now helps to elevate risk values into Days 3 and 4 (7th and 8th). Moderate solar activity is likely to continue with further M-class flares and a slight but reducing chance of isolated X-class flares giving High solar activity.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	40	50	60
Very Active	R3 to R5 X Class	No	10	5	5	10

Figure 3: GOES X-Ray flares



Solar Radiation Storms - (High Energy Protons):

High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels. Although S1 radiation storms have not been observed given recent flare activity implies there remains a slightly increased chance of protons increasing in the immediate term, reverting to the raw risk for the disc at nearer 5% into the new working week. Dominating this risk remains AR3234, which despite rotating around the northwest limb, can still pose a gradual fading risk of an S1 in the next day or so. While yet to appear, the numerous arriving eastern hemisphere spots due in the period should not appreciably contribute to the risk of S1 or greater until later next week.

Radiation Storms	Level ($\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	No	10	10	5	5
Very Active	$\geq \text{S3}$ *	No	5	1	1	1
* $\text{S3} \geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$. (pfu = $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)						

High Energy Electrons Event ($\geq 2\text{MeV}$):

Electron flux is forecast to continue at moderate to high levels perhaps becoming suppressed given any more active geomagnetic activity, however more protracted periods of High levels are eventually expected given current HSS, with this most likely to occur into Day 3 (7th). Electron fluence is forecast to breach the active threshold through Day 1 (5th) and potentially rising a little further and remaining above active levels through the guidance period, although the potential for more significant geomagnetic activity, especially for Days 2 and 4 (6th and 8th) leads to a lowering of confidence.

Electron fluence is currently above the Active threshold ($1\text{e}8$ integrated flux), which is in good agreement with the REFM forecast. Fluence is expected to remain above the Active threshold throughout much of the period, although there is the potential for some geomagnetic activity during the period, which may suppress activity at times - low confidence. Persistence gives a more forceful upwards trend for Days 3 and 4 (7th and 8th) and this is tentatively accepted as a guidance outcome for this period with moderate confidence at best, and probabilities in the table above have been raised to 5% for the $1\text{e}9$ threshold to be reached.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	100	90	80	70
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	5	5

Figure 4: REFM observations, forecast and recurrence

